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(56) Documents Cited
GB 2054256 A
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UK CL (Edition T) **H1D** DKAM DKGB DKGC DKGD DKGE
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Other: **ONLINE: EPODOC, JAPIO, WPI**

(54) Abstract Title
Magnetron with increases stability

(57) A magnetron comprises a plurality of anode vanes 12-19 and straps 20, 21, 22 in contact ith alternate ones of the vanes. Each strap comprises an open ring having two free end portions. The end portions of each pair overlap in a spaced relationship to provide a capacitance in use. The provision of a capacitance in the, or each, strap ring increases the stability of operation of the magnetron in the wanted π mode and limits oscillations at undesired frequencies. Preferably, the capacitance is variable. This may be realised by arranging so that the relative distance between the end portions is adjustable. In a further described embodiment (Fig. 8), an intermediate strap portion (46) is used along with the open ring strap free ends (49, 50) to provide the capacitance.

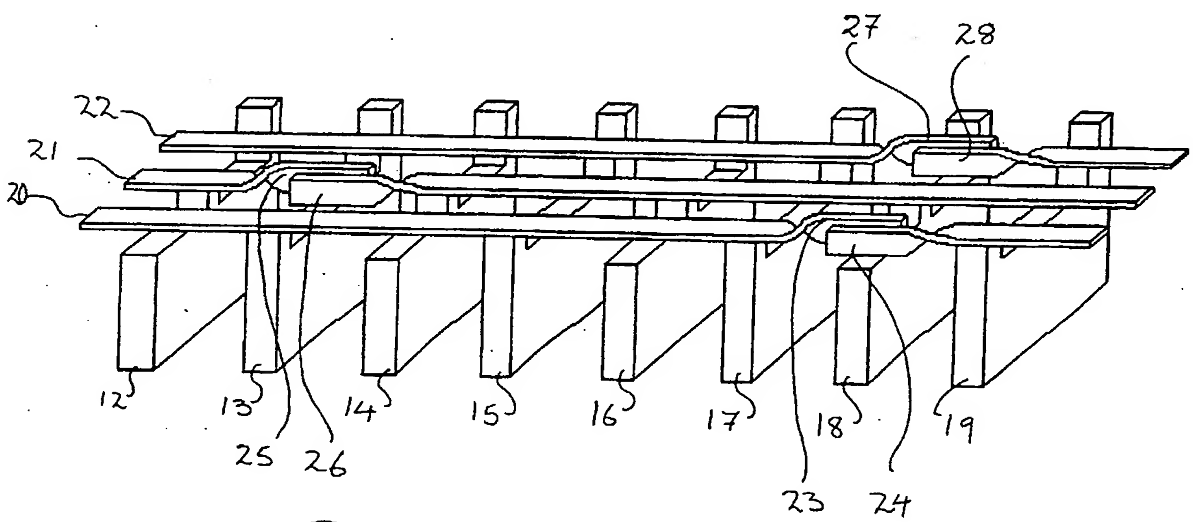

FIG. 3

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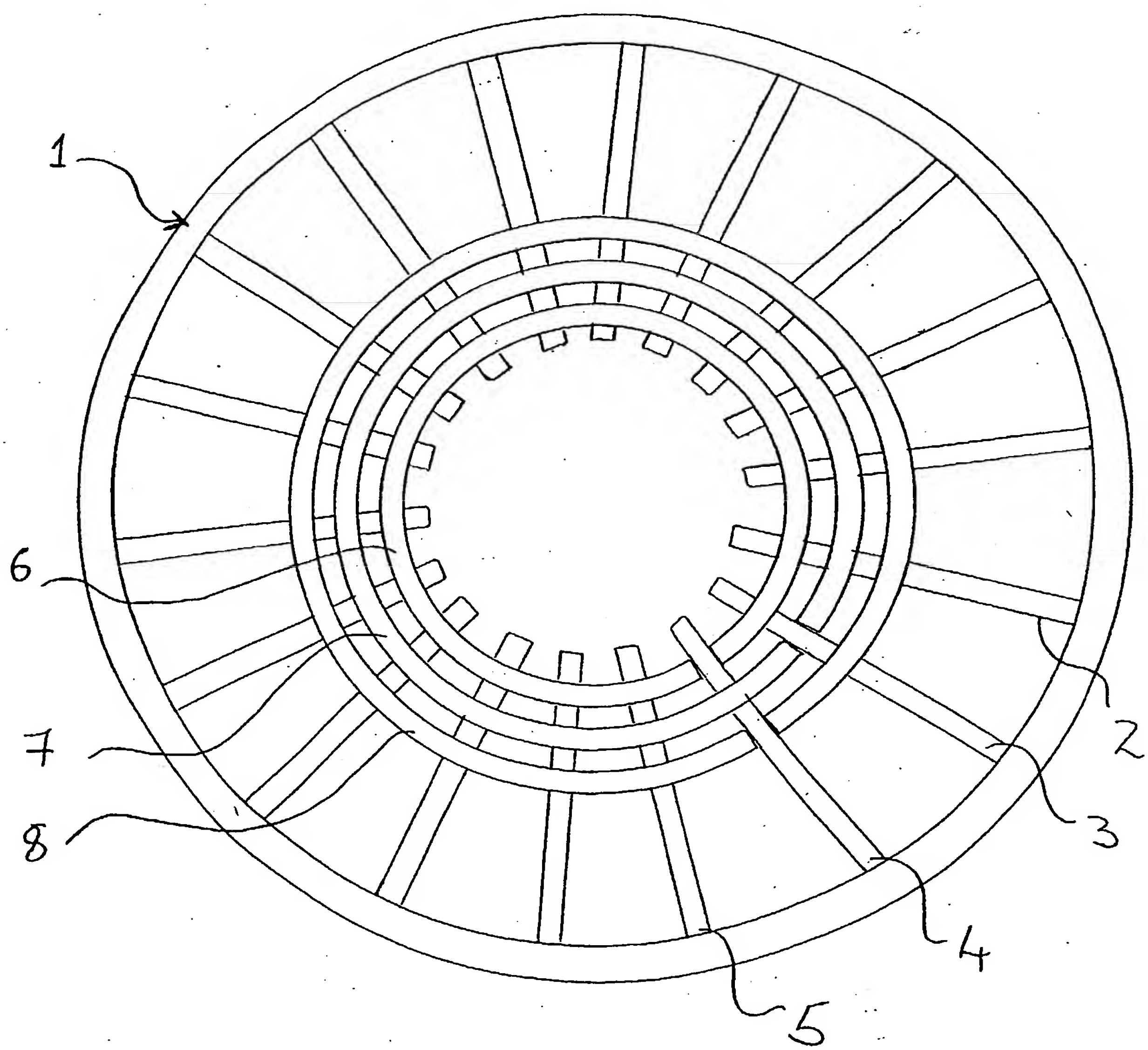

FIG. 1

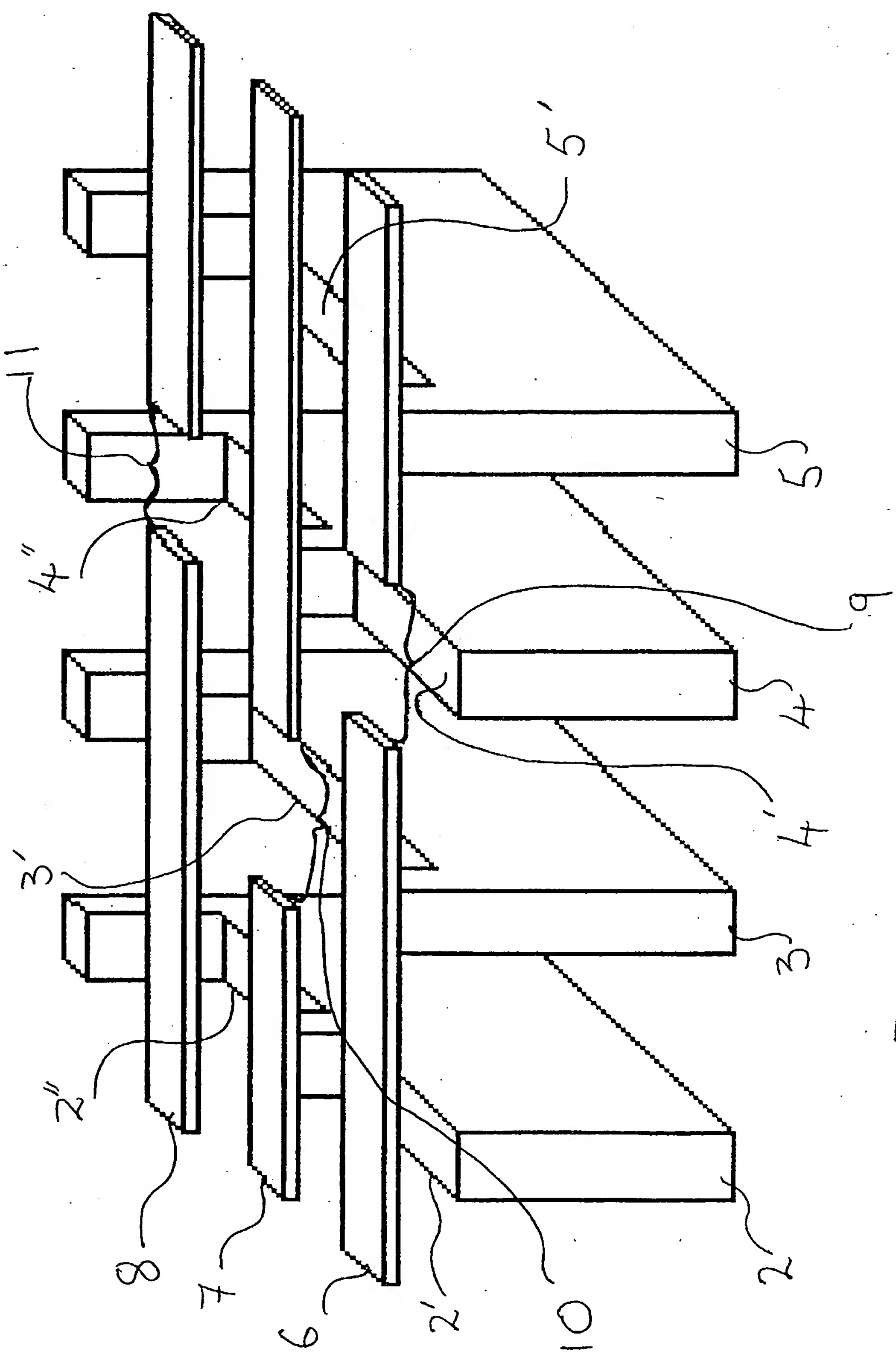

FIG. 2

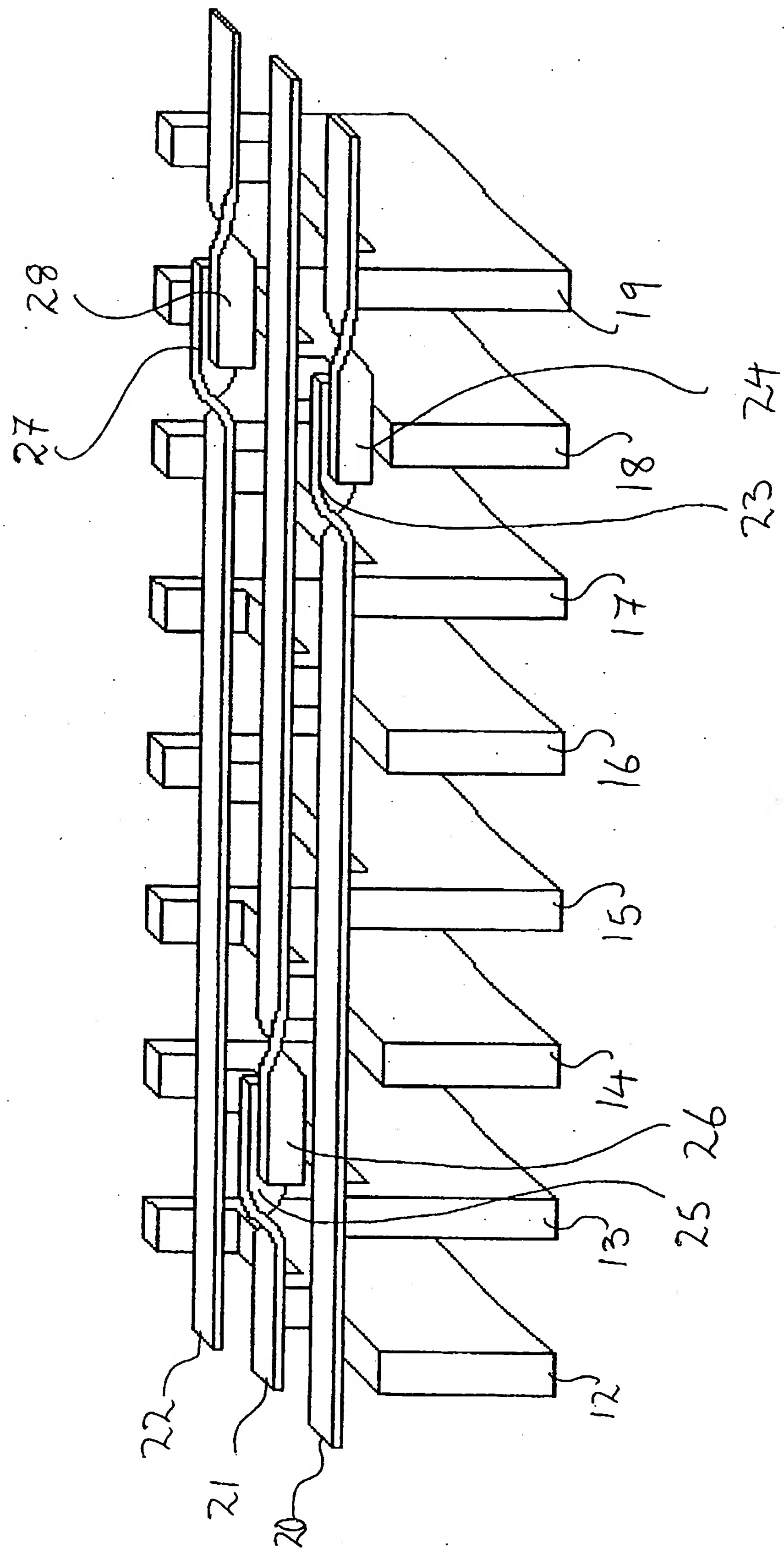

FIG. 3

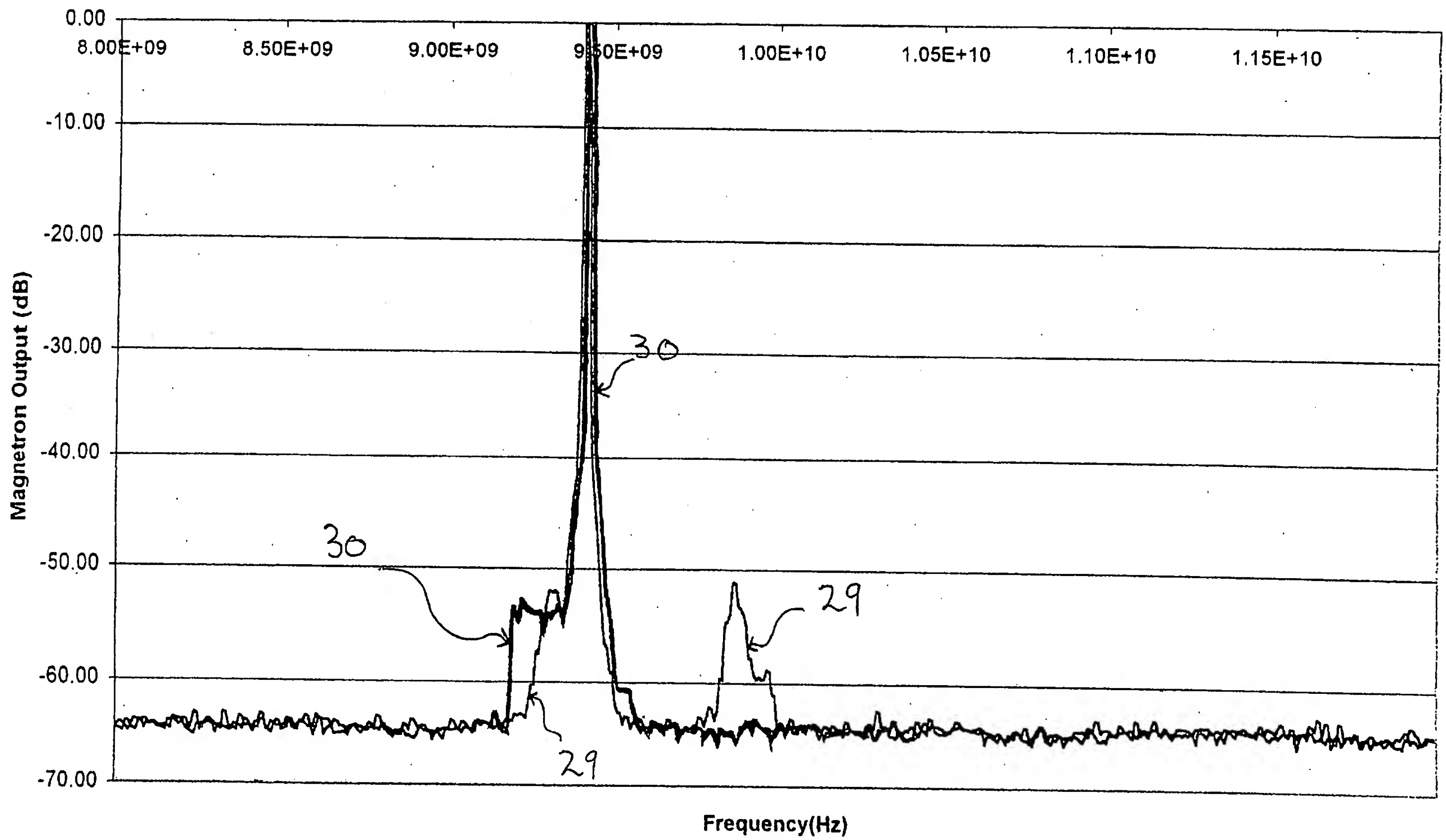
Magnetron Output (dB)
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
8.00E+09
8.50E+09
9.00E+09
9.50E+09
1.00E+10
1.05E+10
1.10E+10
1.15E+10
Frequency(Hz)
30
30
29
29

FIG. 4

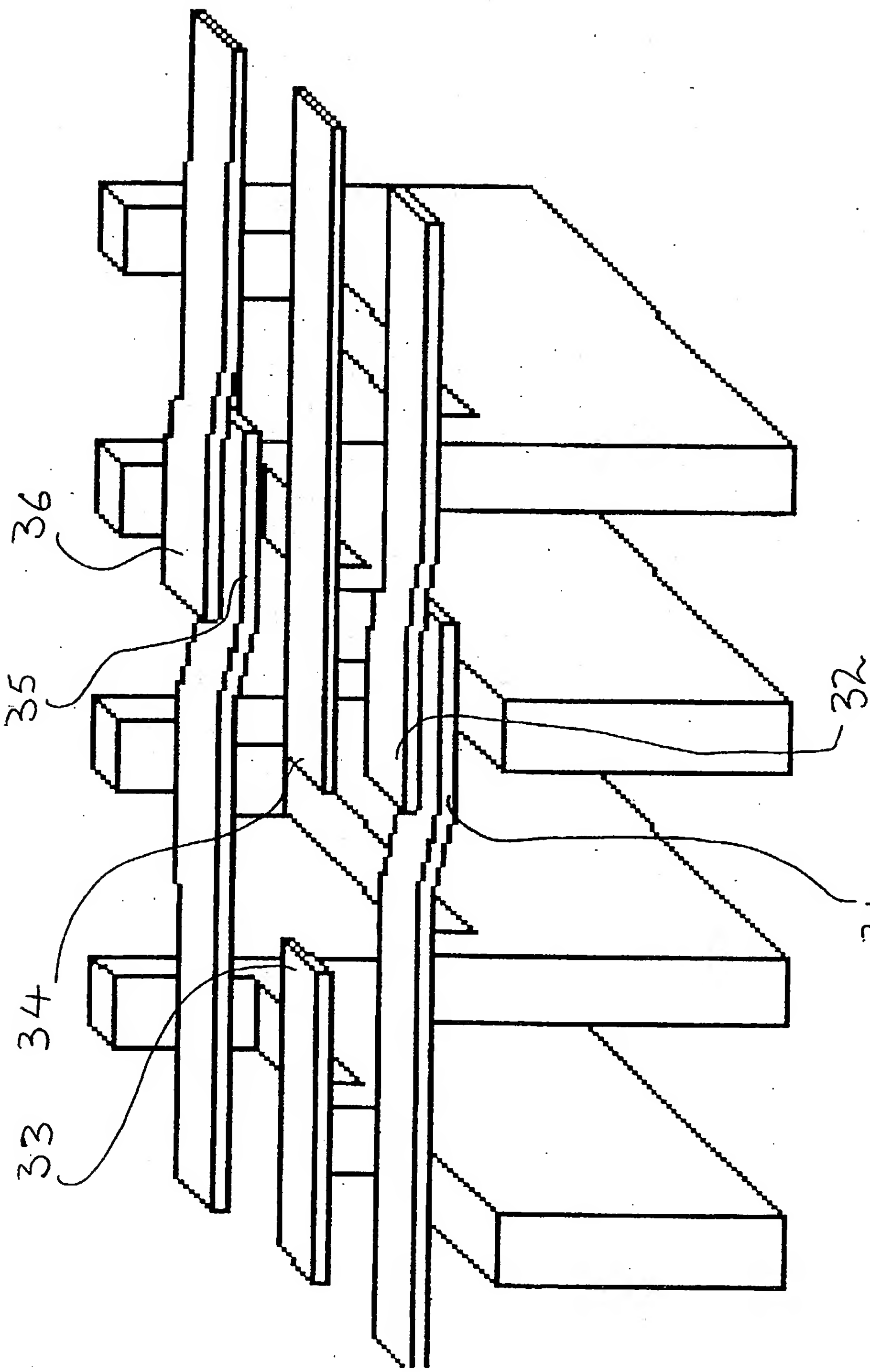

FIG. 5

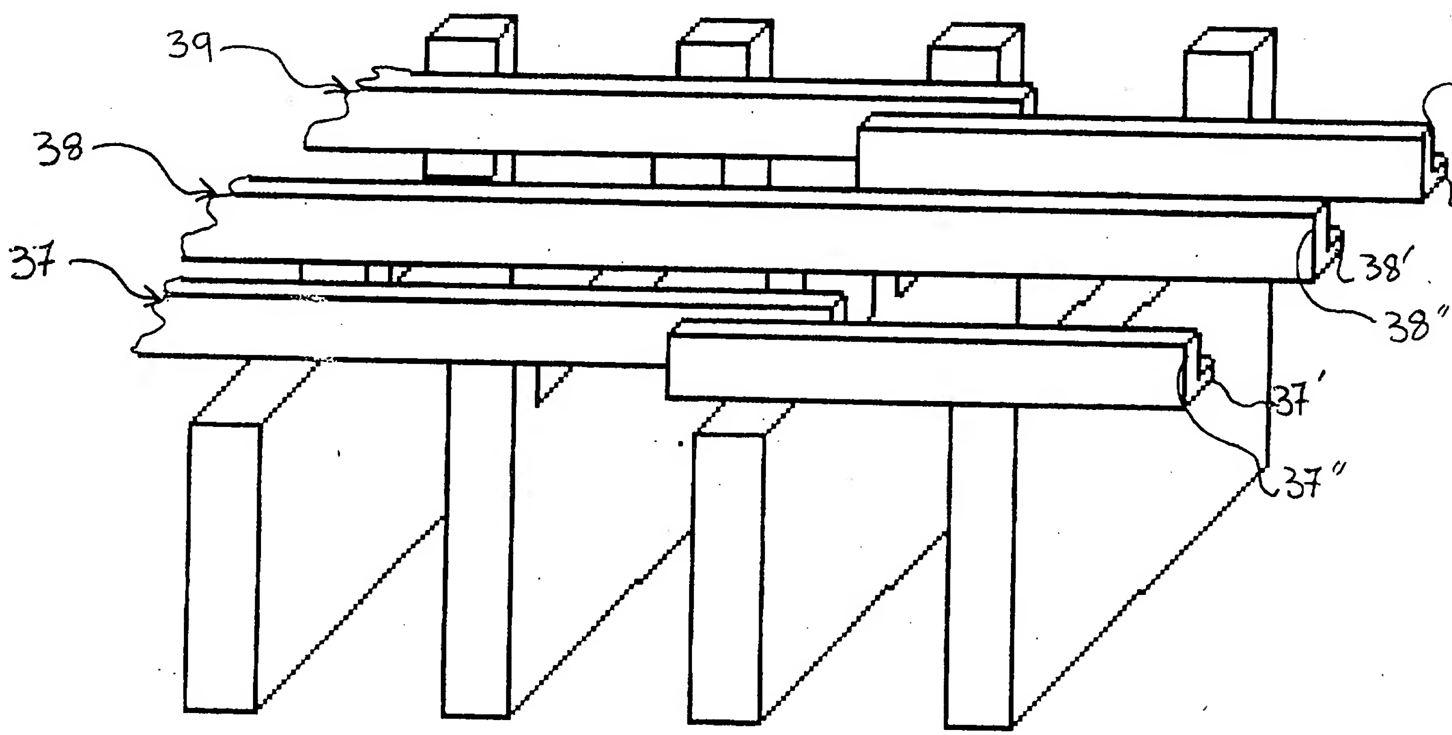

FIG. 6

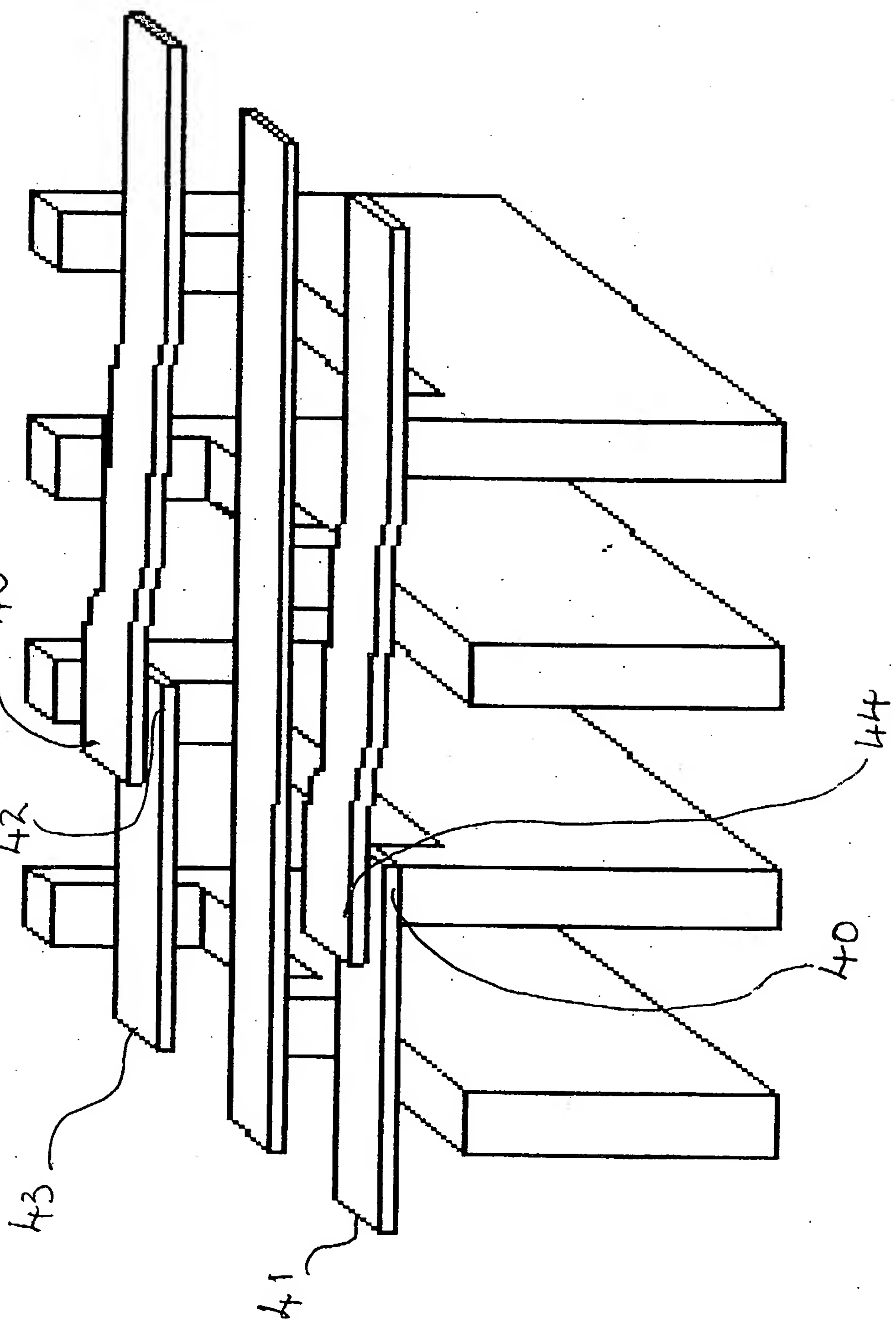

FIG. 7

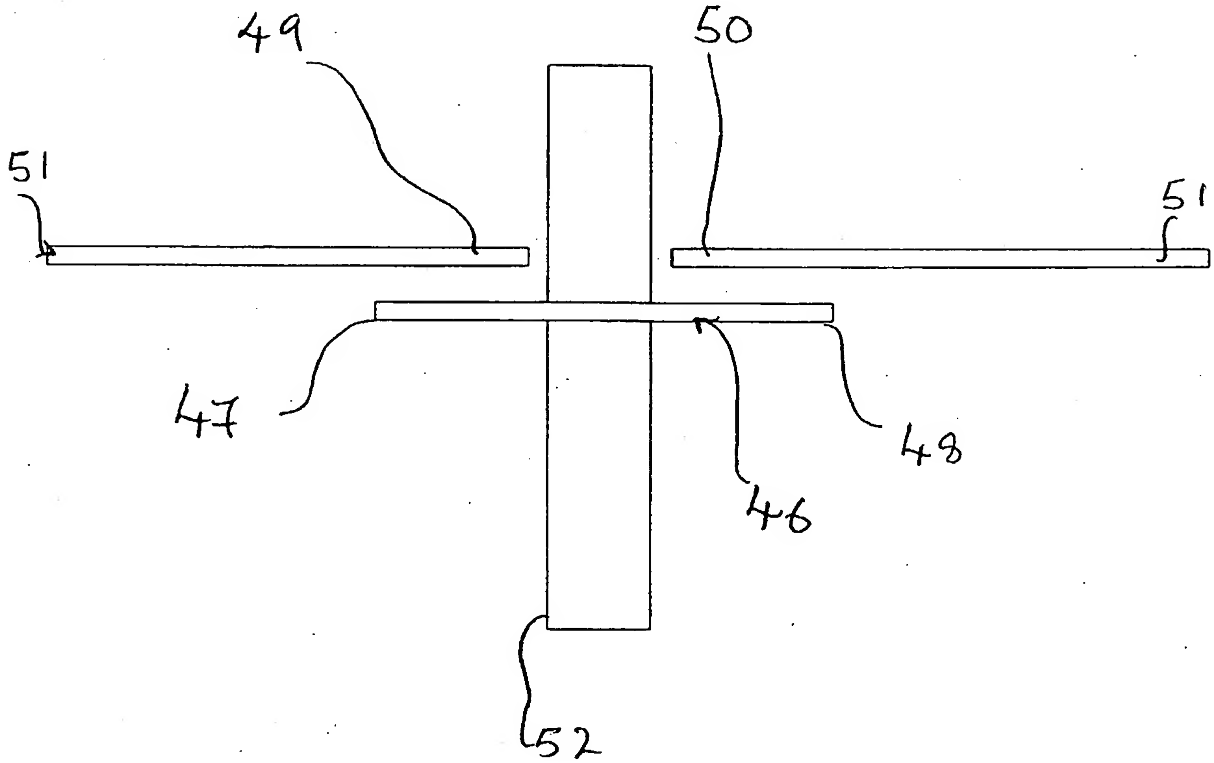

FIG. 8

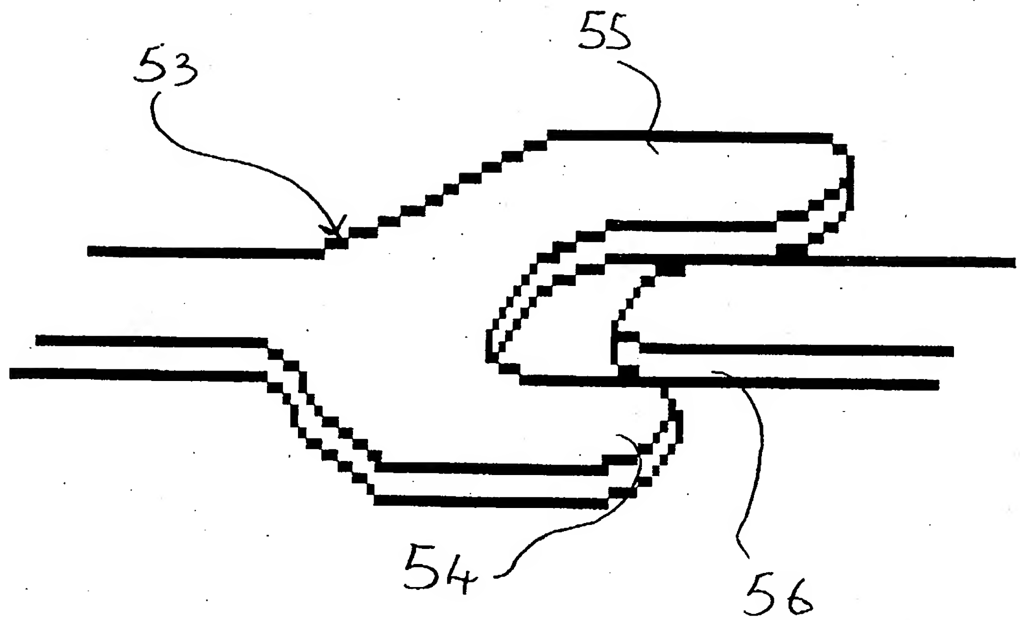

FIG. 9

MAGNETRONS

This invention relates to magnetrons.

Magnetrons are well-known vacuum electron discharge devices used to generate electromagnetic fields in the microwave frequency range. A typical magnetron comprises a cylindrical cathode, a cylindrical anode surrounding the cathode and a plurality of resonant cavities formed in the anode by either slots or vanes. An electric field is established between the cathode and the anode, and a magnetic field is applied perpendicular to the electric field in the so-called interaction region, which is the space between the cathode and the resonant cavities in the anode. When the value of E/H is suitable, electrons emitted from the cathode interact with the electric and magnetic fields to generate microwave energy of a frequency determined by the parameters and the resonance characteristics of the cavities.

A known problem with magnetrons is that of moding; that is, significant cavity responses occur at frequencies other than the frequency for which the magnetron is designed to operate. The concept of anode strapping was devised as a solution to this problem.

Strapping, as conventionally understood, is the joining of alternate anode vanes by means of a closed ring. Each pair of vanes forms a resonant cavity therebetween, and all such cavities are maintained at the same electrical potential. Thus, alternate anode

vanes are locked into operation in the desired mode, known as the π mode, which node has node points of the same distance apart as the distance between alternate vanes.

Conventionally, strap breaks are provided, which serve to disrupt the rf field pattern of unwanted modes in the interaction space. However, a drawback of this approach is that it increases the frequency separation of the modes of operation. Recent proposed ITU regulations place limits on the spread of frequency output of such devices.

The invention provides a magnetron comprising a plurality of anode vanes and a strap in contact with alternate ones of the vanes, the strap comprising an open ring having end portions arranged to overlap in a spaced relationship so as to provide a capacitance in use.

The provision of a capacitance in the strap ring increases the stability of operation of the magnetron in the wanted mode and limits oscillations at undesired frequencies.

Preferably, the capacitance is variable. This may be realised by arranging so that the relative distance between the end portions is adjustable. Alternatively, the effective size of one or each of the end portions could be adjusted to give a corresponding change in capacitance. The provision of a variable capacitance permits the undesired π-1 mode to be retuned to a different frequency range.

Alternatively, the strap arrangement can take the form of an open ring with an intermediate strap member. In this arrangement, the end portions of the ring do not overlap each other, but instead overlap end portions of the intermediate member.

The invention is not limited to magnetrons having vane-type anodes. The arrangement of straps having overlapping end portions may be applied to magnetrons having hole-and-slot type anodes.

A dielectric material and/or an r.f. lossy material may be provided between overlapping end portions. These materials may take the form of coatings on the end portions.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which: -

Figure 1 is a plan view of the anode and strap arrangement of a conventional magnetron;

Figure 2 is a perspective view of vanes of the anode arrangement of Figure 1;

Figure 3 is a perspective view of the anode vanes and strap arrangement of a magnetron constructed according to the invention;

Figure 4 is a graph illustrating magnetron output power against frequency, for both a conventional magnetron and one constructed according to the invention;

Figure 5 is a perspective view of anode vanes and a strap arrangement of a magnetron constructed according to an alternative embodiment of the invention;

Figure 6 is a perspective view of anode vanes and a strap arrangement of a magnetron constructed according to a further alternative embodiment of the invention;

Figure 7 is a perspective view of anode vanes and a strap arrangement of a magnetron constructed according to a further alternative embodiment of the invention;

Figure 8 is a front view, partly in section, of an anode vane and strap arrangement of a magnetron constructed according to a further alternative embodiment of the invention; and

Figure 9 illustrates a strap arrangement for a magnetron constructed according to a further alternative embodiment of the invention.

Like reference numerals have been given to like parts throughout the specification.

With reference to Figures 1 and 2, a conventional typical anode arrangement is illustrated. The anode arrangement comprises a cylindrical anode wall, indicated generally by the reference numeral 1, and a plurality of anode vanes, four of which 2-5

are illustrated in both Figures 1 and 2. The anode vanes extend radially inwardly from the inner wall of the cylindrical anode 1. A plurality of straps 6, 7, and 8 for the vanes are also illustrated. Strap 6 contacts alternate anode vanes, such as vanes 3 and 5, and is spaced from the other vanes, such as vanes 2 and 4. Cut-out regions 2′, 2″ and 4′, 4″in the vanes 2 and 4 respectively help to ensure that the strap 6 does not come into contact with these vanes. Strap 7 contacts those anode vanes that are not contacted by the strap 6 i.e. it contacts vanes 2 and 4. This strap is also spaced from the other alternate vanes, such as vanes 3 and 5. Similar cut-outs 3′ and 5′ in vanes 3 and 5 respectively help to ensure that the strap 7 does not come into contact with them. The third strap 8 is in contact with the same vanes as is the strap 6. The purpose of this extra strap is to balance the π mode r.f. field at the cathode. This is described in our UK Patent No.2054256.

The straps 6, 7, 8 comprise concentric rings, typically made of silver-plated copper. The rings shown in Figures 1 and 2 are open rings; i.e. they each have a so-called strap break 9 to 11 respectively. Typically, the breaks 9 to 11 are a little longer than the width of a vane, although this need not be the case. In this drawing, the strap breaks 9 to 11 are located over anode vanes, but other arrangements are possible. Although the strap breaks 9 to 11 are necessary to prohibit flow of current between the vanes, they tend to cause greater frequency separation between the π mode of operation and the π-1 mode.

Part of a magnetron constructed according to the invention is shown in Figure 3. There is a plurality of vanes 12 to 19, alternate ones of which are connected electrically by

straps 20 to 22 comprising open rings. Straps 20 and 22 electrically connect vanes 13, 15, 17 and 19. Strap 21 electrically connects vanes 12, 14, 16 and 18. Each strap has a pair of end portions that define the corresponding strap break. Strap 20 has end portions 23 and 24, strap 21 has end portions 25 and 26 and strap 22 has end portions 27 and 28. In accordance with the invention, the end portions of each pair are extended and overlap to the extent that they function as the plates of a capacitor.

The capacitance thus provided helps to stabilise the desired π mode of operation of the magnetron by limiting the start-up gain of the π-1 mode. The ends 23 to 28 of the straps have been flattened in this embodiment to increase further the available capacitance.

In this embodiment, the end portions 23 to 28 of the straps are not fixed. Thus the capacitance provided by the ends 23 to 28 may be varied by adjusting the separation of the overlapping free end portions. This may be effected by moving either end portion or both end portions of each pair. An alternative method of changing the capacitance is to change the effective size of one or both of the end portions.

The provision of a selectively variable capacitance permits the π-1 mode of operation to be tuned to a different frequency whilst leaving the frequency of operation of the π mode largely unaffected. This is illustrated by the graph of Figure 4.

This graph represents the magnetron output across a range of frequencies (the X-band). The line indicated by the reference numeral 29 represents the output from a magnetron employing a conventional strapping arrangement, such as that shown in Figures 1 and 2.

The main output peak occurs at approximately 9.45 GHz, which represents the π mode, i.e., the desired mode of operation. However, there is a secondary peak occurring at approximately 9.95 GHz. This represents the undesired π -1 mode of operation.

The bold line on the graph, represented by the reference numeral 30, represents the output achievable from a magnetron constructed according to the invention. The provision of a capacitance, particularly a variable one, between the free end portions of each strap, permits the π -1 mode to be retuned to a lower frequency band. In this drawing, the secondary peak associated with the π -1 mode is just discernible to the left of the primary peak associated with the π mode. It is noteworthy that this has had negligible effect on the frequency of the π mode.

The embodiment of Figure 3 shows the free end portions in a side-by-side spaced relationship. In the alternative embodiment of Figure 5, the straps have free end portions 31 to 36, some of which are arranged to overlap, one above the other. In Figure 5, the end portion 32 of the first strap is located over the end portion 31. The end portions 33 and 34 of the second strap do not overlap, but provide a conventional strap break. The end portion 35 of the third strap overlaps over the end portion 36.

In the alternative arrangement of Figure 6, the straps 37-39 have an "L"-shaped cross-section, i.e. part 37′, 38′, 39′ of the strap is horizontal, and part 37″, 38″, 39″ is upstanding. The horizontal part 37′, 38′, 39′ of the strap is attachable to alternate anode vanes. Straps 37 and 39 have strap breaks, and the end portions of these straps are arranged to overlap. This strap arrangement is simple to manufacture, is easily attached

to the vanes and is also mechanically stable. This type of arrangement need not take on this exact configuration. For example, the upstanding portions 37″, 39″ of the straps 37, 39 may be arranged back-to-back in a spaced relationship, so that the horizontal parts 37′, 39′ are not located between the region of overlap. Alternatively, or additionally, the straps may be mounted with the horizontal parts 37′, 39′ uppermost.

Figure 7 illustrates an embodiment wherein not all of the end portions are free. In this arrangement, end portion 40 of strap 41 and end portion 42 of strap 43 are affixed to the same anode vane at different points. The other corresponding end portions 44, 45 of straps 41, 43 are free and overlap the fixed end portions 40, 42 respectively. The free end portions 44, 45 can be moved in order to vary the available capacitance to a desired magnitude.

Of course, the invention is not limited to strap arrangements having just two end portions. In the arrangement of Figure 8, an intermediate strap member 46 is provided having two end portions 47, 48. Each end portion 47, 48 is arranged to overlap, in a spaced relationship, respective end portions 49, 50 of an open ring-type strap 51. The intermediate strap 46 is affixed to a vane 52. The end portions 49, 50 of the ring may be free, so that the capacitance provided by either or both overlapping regions may be varied.

Figure 9 illustrates part of a strap suitable for putting into effect a further variant of the invention. In this drawing, one of the end portions 53 has tines 54, 55. The corresponding other end portion 56 is interposed between these tines, so that the area of

overlap is located between the tines. Of course, both end portions could have a plurality of tines, arranged so that the tines of one end portion are interpolated with the tines of the other end portion to form an interdigital-type capacitor.

Further variations may be made without departing from the scope of the invention. For example, more or fewer anode vane straps may be provided, and not all of these need be arranged to provide capacitance. A combination of fixed and variable capacitance may be provided by arranging for some free end portions to be held in a fixed spaced relationship, while other end portions can be arranged to be movable.

As a further variation, a dielectric medium may be provided between the free end portions to improve capacitance further. This medium may be deformable to allow adjustment of the relative positions of the end portions. The dielectric may take the form of a coating on the end portions.

An r.f. lossy material may be provided between the overlapping portions, and this may also take the form of a coating.

The invention is also applicable to magnetrons having different anode structures, for example, the hole-and-slot type anode.

CLAIMS

1. A magnetron comprising a plurality of anode vanes and a strap in contact with alternate ones of the vanes, the strap comprising an open ring having end portions arranged to overlap in a spaced relationship so as to provide a capacitance in use.

2. A magnetron comprising a plurality of anode vanes and a strap arrangement comprising an open ring in contact with alternate ones of the vanes, the ring having end portions, and an intermediate strap member having at least one end portion, wherein an end portion of the intermediate strap member is arranged to overlap an end portion of the ring in a spaced relationship so as to provide a capacitance in use.

3. A magnetron comprising an anode of the hole-and-slot type and a strap arrangement for the anode having end portions arranged to overlap in a spaced relationship so as to provide a capacitance in use.

4. A magnetron as claimed in any preceding claim, wherein the spaced relationship is variable, so that a variable capacitance is provided.

5. A magnetron as claimed in claim 4, wherein the spaced relationship is varied by adjustment of the position of at least one of the end portions.

6. A magnetron as claimed in claim 5, wherein at least some of the end portions are free, and the spaced relationship is varied by adjustment of at least one of the free end portions.

7. A magnetron as claimed in any preceding claim, further comprising a dielectric medium between overlapping end portions.

8. A magnetron as claimed in claim 7, wherein at least one end portion is coated with the dielectric medium.

9. A magnetron as claimed in any preceding claim, further comprising an r.f. lossy material between overlapping end portions.

10. A magnetron as claimed in claim 9, wherein at least one end portion is coated with the r.f. lossy material.

11. A magnetron, substantially as hereinbefore described with reference to, or as illustrated in, the accompanying drawings.

12. A strap arrangement for a magnetron, comprising an open ring having two end portions, wherein the end portions overlap in a spaced relationship.

13. A strap arrangement for a magnetron, comprising an open ring having two end portions and an intermediate strap member having at least one end portion, wherein an end portion of the intermediate strap member is arranged to overlap an end portion of the ring in a spaced relationship.

14. A method of operating a magnetron, including the step of stabilising the π mode of operation by providing a capacitance between the free end portions of an anode strap comprising an open ring.

15. A method as claimed in claim 14, further comprising the step of tuning the π-1 mode to within a desired range of frequencies by arranging the capacitance to be variable.

16. A method of operating a magnetron, substantially as herein before described with reference to, or as illustrated in, the accompanying drawings.

Application No:	GB 0117231.1	**Examiner:**	Carol Ann McQueen
Claims searched:	1 - 13	**Date of search:**	15 January 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H1D (DKAM, DKGA, DKGB, DKGC, DKGD, DKGE)

Int Cl (Ed.7): H01J 23/00, 23/18, 23/20, 23/22, 23/207, 23/213, 25/00, 25/50, 25/52, 25/58, 25/587, 25/593.

Other: ONLINE: EPODOC, WPI, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2054256 A	(ENGLISH ELECTRIC VALVE COMPANY) Abstract, Figures and straps 17, 18 and 19.	1, 2, 3, 12 and 13
A	JP 040118835 A	(JAPAN RADIO CO LTD) Abstract, Figure 1(a) and straps 4a and 4b.	1, 2, 3, 12 and 13
A	US 3176188	(GENERAL ELECTRIC COMPANY) See Fig. 6 and 17, straps 80, 81, 82, 83, 144 and 145, col. 7, lines 3 to 25.	1, 2, 3, 12 and 13
A	US 2444418	(GENERAL ELECTRIC) See straps 62-69 in Fig. 2.	1, 2, 3, 12 and 13
A	US 2408235	(RAYTHEON MFG CO) See overlapping straps 31 and 32 in Fig 2, and col. 3 lines 1 to 4.	1, 2, 3, 12 and 13

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		

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